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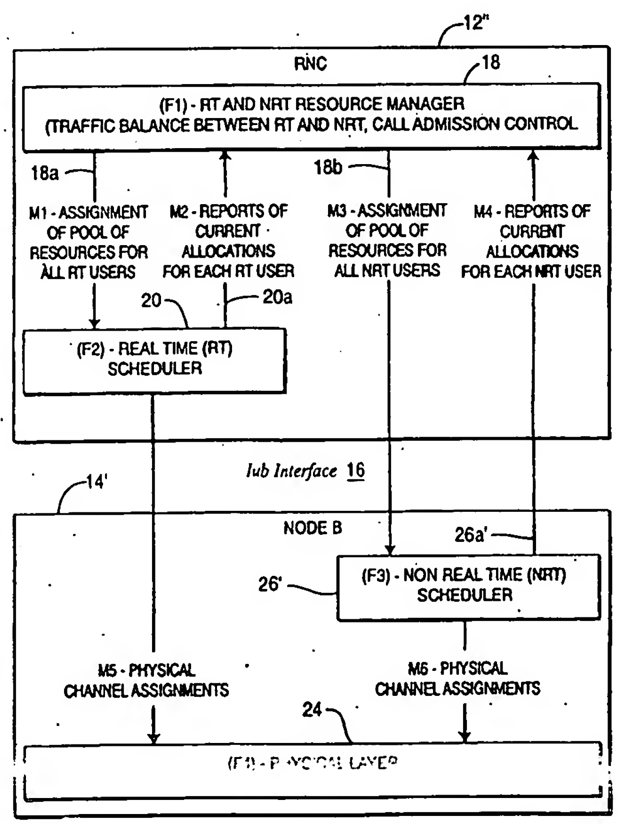
[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR COORDINATING A RADIO NETWORK CONTROLLER AND NODE B RESOURCE MANAGEMENT DEVICE FOR HIGH SPEED DOWNLINK PACKET DATA SERVICE



(57) Abstract: A method and apparatus for enabling resource management (18) of a radio network controller (12'') interfacing with NodeB (14'), wherein the RNC (12'') having means for assigning resources to real time and non real time users (18), means for providing physical channel assignments for RT resources (20) and means for coupling (16), wherein the Node B (14') having means for providing physical channel assignments for NRT resources (26') and means for providing reports of current allocations for each NRT user (26').

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

[0001] METHOD AND APPARATUS FOR COORDINATING A RADIO NETWORK CONTROLLER AND NODE B RESOURCE MANAGEMENT DEVICE FOR HIGH SPEED DOWNLINK PACKET DATA SERVICE

[0002] FIELD OF INVENTION

[0003] The invention relates to radio resource management in a wireless communication system. More particularly the invention relates to communication of data necessary for resource management in high speed downlink packet access service.

[0004] BACKGROUND OF THE INVENTION

[0005] In 3rd generation cellular systems for TDD and FDD, almost all resources are fully allocated and controlled by the Controlling Radio Network Controller (C-RNC) that controls the Node B radio resources. For Dedicated Channels (DCH), the C-RNC allocates a fixed amount of resources from the resource pool and assigns it to service the DCH. An example of a DCH service is voice services. For data type services, the C-RNC can allocate Downlink Shared Channels (DSCH). Examples of a DSCH service are data services such as Web download, file transfer protocol (Ftp) services or e-mail. Multiple users share this channel over time, and the scheduling of this channel, for example, which user gets access to the channel, is performed in the C-RNC.

[0006] These resources are managed by the C-RNC which can decide how much of the resources of a cell is allocated to DCH services and how much is allocated to DSCH services because each resource can only serve one type of service (DCH or DSCH) at a single moment, however resources can be moved back and forth between the two resource pools as is needed.

[0007] An additional complexity occurs in the resource allocation of the DSCH in the C-RNC since it is a shared resource that handles multiple services of variable data rates. The maximum amount of resources that are requested by the sum of the users can frequently exceed the amount of the resources in the pool allocated to this type of service. This is possible since all users statistically

data service users need to be monitored to determine not only that the radio resources are utilized efficiently but also that the users are not excessively over-provisioned on the available resource, since either condition would cause the users Quality of Service (QoS) to deteriorate.

[0008] The C-RNC must answer the following general questions to have optimal knowledge of the operation of the high-speed downlink packet access (HSDPA) service. The first question is, how well is the QoS requirement fulfilled for each user? Particularly, it would need to determine whether all of the operational parameters are set to optimal levels for both the shared and dedicated services. The second question is how well are the overall resources utilized by the two types of services (dedicated and shared service)? Is there an optimal resource split between dedicated and shared services given the current usage/demand of each service?

[0009] Yet another question is how much does it cost the overall system performance by adding a user of certain QoS requirement to the cell? This is particularly an issue for shared services where the service rates a user really needs are usually variable over time and the resource allocated to the user is usually over-provisioned.

[0010] In most services the C-RNC can readily answer these questions. For a particular user with dedicated service, the C-RNC allocates a fixed amount of resources since the amount of resource used by the user is pretty static over time. For a user of variable data rates with shared service, the C-RNC has enough information to understand how well resources are being used among the users.

[0011] However, the High Speed Downlink Packet Access (HSDPA) service uses a new channel; a High Speed Downlink Shared Channel (HS-DSCH) to provide higher data rates for data services than the DSCH. The HS-DSCH service is based on the Node B more dynamically adapting the transmission to better service the users that have data to be transmitted. Therefore the C-RNC no longer schedules the data to be transmitted at a particular moment or the actual resources used for that transmission. The C-RNC basically assigns a given amount of power and the resources in the data resource pool to the Node B and

the Node B dynamically schedules the users' data based on current radio conditions.

[0012] The consequences of this architecture change in the functionality of data services in the C-RNC leaves it without some of the basic information it has had for other services. Consequently, questions asked before such as: (1) how well the QoS has been fulfilled; (2) the overall resource utilization; and (3) the effect of adding a user to the system, can not be completely answered.

[0013] SUMMARY OF THE INVENTION

[0014] The architecture of the high-speed shared service means that the Node B has various sets of information that answer the three (3) sets of basic questions that a data service would need to have answered. The present invention provides an HSDPA- capable Node B with a scheduler providing information enabling a resource manager to efficiently allocate resources.

[0015] BRIEF DESCRIPTION OF THE FIGURES

[0016] The present invention will be understood from a consideration of the figures, wherein like elements are designated by like numerals and wherein:

[0017] Figures 1 and 2 are diagrams showing a radio network controller (RNC) interfaced with a Node B wherein Figure 1 lacks a high-speed, downlink shared channel (HS-DSCH) and Figure 2 has an HS-DSCH channel.

[0018] Figure 3 shows an RNC interface with a Node B having an HS-DSCH channel and embodying the principles of the present invention.

[0019] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] High speed downlink packet data access (HSDPA) has been provided to increase capacity, reduce round-trip delay and increase peak data rates through a high speed down link shared channel (HS-DSCH). In addition, three (3) fundamental technologies which are tightly coupled and rely on the rapid adaptation of the transmission parameters to instantaneous radio conditions include:

(a) fast link adaptation technology enabling the use of modifications in modulation responsive to channel conditions such as fading peak and fading dip;

(b) fast hybrid automatic-repeat-request (ARQ) technology for rapidly requesting retransmission of missing data entities and combining soft information from original transmission and any subsequent retransmissions before any attempts are made to decode the message; and

(c) fast scheduling of users sharing the HS-DSCH which, through multi-user diversity, is able to transmit to users with favorable radio conditions.

[0021] The technologies employed by HSDPA utilized rapid adaptation of transmission of parameters to match channel conditions and functions such as fast link adaptation and fast scheduling are thus placed close to the air interface, namely at the Node B, causing parts of the functionality previously performed at the radio network controller (RNC) to be moved to the Node B, forming a new Node B entity, MAC-HSDPA. Extending the features of the Node B in this manner provides a highly reliable channel that supports high data rates.

[0022] Figures 1-3 show a typical implementation and the various message flows necessary for proper radio resource management (RRM) functionality. Figure 1 is a diagram showing the related art before HSDPA was created. Figure 2 is a diagram showing the related art interacting with the HSDPA changes. Figure 3 is a diagram showing correct functionality employing the concept of the present invention.

[0023] Figure 1 shows an RNC 12 and Node B 14, and some of the high level functions and messaging necessary for proper functionality of RRM allocation of real time (RT) and non-real time (NRT) services. The defined functions and messaging within a Node (RNC or Node B) is highly dependent on implementation. Within a node, the labeled functions can be performed by separate processors, or can be within a combined task performing the tasks of more than one function and the tasks that perform these functions may perform other functions unrelated to this invention. Between the RNC 12 and Node B 14

is the standardized Iub interface 16, and thus the messaging is formally defined within the appropriate standards.

[0024] Function 1 (F1) is the RT and NRT Resource manager 18. This function performs the traffic balance functions, giving out the pool of resources to real time (RT) and non-real time (NRT) functions plus performing the call admission control function, which determines, given the current load, whether the cell can accommodate a new user of a particular type, data rate and QoS attributes.

[0025] Function 2 (F2) is the Real Time Scheduler 20. The real time scheduler 20 is responsible for assigning resources to real time subscribers like voice users. Given the type of traffic, the allocations are usually static once assigned.

[0026] Function 3 (F3) is the Non-Real Time Scheduler 22. The non-real time scheduler is responsible for assigning resources for each burst of data for non-real time users. Given the type of traffic, the allocations are relatively frequent and many would occur for the typical non-real time call.

[0027] Function 4 (F4) is the Physical Layer 24. Layer 24 performs all of the physical air interface functions to properly send the user's data over the air interface. The resources used for each transmission are assigned by the Real Time or Non-Real Time schedulers.

[0028] Each of the functions F1 to F3 communicate to each of the other functions F1 to F3 using some type of message sets. These sets can be formally defined by the standards (e.g. message sets that travel over the Iub interface) or can be internally defined and thus implementation specific. In fact, in an implementation using a single task performing more than one function, the communication can be trivial. It should be noted, however, that this implementation just concerns the logical messages that need to be passed between functions. It should also be noted that these functions, even if implemented in software exactly as described in the figures, will have other message sets that they will need to exchange with other functions, including those which are outside of the scope of this invention.

[0029] Message Set 1 (M1) 18a is the set of messages that are used so that the RT and NRT Resource manager can assign a pool of current resources for RT calls so that the Real time scheduler (F2) has the information it needs.

[0030] Message Set 2 (M2) 20a is the set of messages that are used so that the RT and NRT Resource Manager can know the current allocations to the RT users. Given that RT allocations are usually static, these messages are trivial unless severe congestion exists.

[0031] Message Set 3 (M3) 18b is the set of messages that are used so that the RT and NRT Resource manager 18 can assign a pool of current resources for all NRT allocations so that the Non-Real time scheduler (F3) has the information it needs so that it can allocate resources.

[0032] Message Set 4 (M4) 22a is the set of messages that are used so that the RT and NRT Resource manager 18 can know the current allocations (i.e. the results or measurements of the allocations) to the NRT users. Since resources are assigned periodically due to bursty traffic, this feedback is important so that the RT and NRT Resource Manager 18 can alleviate any congestion caused by a temporary (or even more than temporary) congestion due to over-subscription.

[0033] Message Set 5 (M5) 20b is the set of messages to tell the layer one (physical layer) about the allocation of resources to a user for RT services.

[0034] Message Set 6 (M6) 22b is the set of messages to tell the layer one (physical layer) about the allocation of resources to a user for NRT services.

[0035] In Figure 2, it should be noted that the M1-M4 message sets are internal to the RNC since the RT and NRT Resource Manager and the RT and NRT schedulers are also located in the RNC. The message sets M5 and M6 are sent as part of standardized Iub messages.

[0036] The diagram of Figure 2 shows the addition of the HS-DSCH channels to handle NRT services. Note that for the new HS-DSCH the Non Real time scheduler 26 is moved to the Node B, and message set 3 (18a) is now sent over the standardized Iub interface and note that Message set 4 is omitted. This means that the RT and NRT Resource manager does not have any feedback from the Non Real Time Scheduler to allow it to balance traffic between RT and NRT

service or provide input into the call admission control functions involving NRT services.

[0037] The diagram of Figure 3 shows the HS-DSCH incorporating the present invention. The new messages M4, 26a[1] defined over the standardized Iub interface would allow for the RT and NRT Resource manager to get feedback to provide proper traffic balancing and call admission control. The new message set M4 will be defined in a similar manner as other physical layer measurements in the Node B, which is prior art. As per the prior art, the CRNC can schedule the reporting and desired averaging over time to fulfill its needs. As was pointed out above, examples of the basic questions that the data service needs to answer, one example is how well is the quality of service (QoS) fulfilled? In this aspect the Node B knows how many times it attempted to transmit data until it was successfully received and thus knows the actual rate data that was transmitted at any one time. This is a different value than the data actually transmitted by a user since a transmission that has to be retried several times will take up capacity of the channel each time it is transmitted even though the user has sent the data only once and thus only counts once in determining how the user's QoS is fulfilled. The present invention however, provides the required information.

[0038] Additionally, it knows other things such as the total power used by the high speed data service compared to the power used by other services offered by the cell, which is an additional factor in knowing how efficiently the allocated power is being used vs. the amount of data processed. There are many other potential measurements that the Node B can make that are useful in determining the quality of the high speed data service. One example is the reliability of the received positive or negative acknowledgements sent by the user to the Node B when data is received correctly or incorrectly.

[0039] Other questions that this type of data can answer are:

(a) How well are the overall resources utilized by the two types of services?

(b) Are the resources split optimally between dedicated and data services given the current usage/demand of each service? The Node B for this

question knows how efficiently the users data was transmitted. For example, one Node B that has more retransmissions than another Node B can not handle as much user data as the other Node B is able to do.

(c) How much does it cost the overall system performance by adding a user of a certain QoS requirement to the cell? The Node B, to answer this question, can estimate the available resources that are available to a new user given the answers above on the overall resource utilization.

[0040] Therefore, since the Node B has all of this information which is necessary to perform these functions, and given that it is not efficient to make an architectural change to move all of the C-RNC resource allocation to the Node B for both dedicated and all data services, it is extremely valuable that the Node B must report these parameters to the C-RNC to allow the C-RNC to incorporate this information together with other information it has on DCH and DSCH resources to allow it to make optimal resource allocation decisions. A list of the potential information would be desirable to pass from the Node B to the C-RNC measured either for the cell in its entirety or by the priority class of the user is: the amount of data successfully transmitted per unit time in a measure such as the number of blocks of data or the size of the actual data transmitted. Also included in the list are: the number of successful transmissions; successful in the first transmission; successful in the second transmission; successful in the third transmission; the number of unsuccessful transmissions; abandoned in the first transmission; abandoned in the second transmission; abandoned in the third transmission; total failures; usage of each modulation scheme; performance of soft handover situations vs. normal situations; ACK/NAK reception quality errors; and power usage for HSDPA transmissions.

[0041] Although the present invention has been described in detail, it is to be understood that the invention is not limited thereto, and that various changes can be made therein without departing from the spirit and scope of the invention, which is defined by the attached claims.

* * *

CLAIMS

What is claimed is:

1. A method for enabling resource management of a radio network controller (RNC) interfaced with a Node B, said RNC assigning resources to Real Time and Non Real Time users;

(a) said RNC providing physical channel assignments to the Node B responsive to assignment of Real time resources;

(b) said RNC coupling assignment of resources for Non-Real Time users to said Node B;

(c) said Node B providing physical channel assignments for Non-Real Time resources to a physical layer responsive to the assignment of resources for Non-Real Time users provided by the RNC; and

(d) said Node B providing reports of the results of current allocations for each NRT user to said RNC.

2. The method of claim 1 wherein step (d) includes providing an amount of data successfully transmitted per unit time to said RNC.

3. The method of claim 2 wherein the amount of data successfully transmitted per unit time includes presenting one of a number of blocks of data and a size of actual data transmitted.

4. The method of claim 2 wherein the information provided in step (d) includes transmitting a number of successful first transmissions.

5. The method of claim 2 wherein the information provided in step (d) includes transmitting a number of successful second transmissions.

6. The method of claim 2 wherein information provided in step (d) includes transmitting a number of successful third transmissions.

7. The method of claim 2 wherein information provided in step (d) includes transmitting a number of unsuccessful transmissions.

8. The method of claim 2 wherein information provided in step (d) includes transmitting a number of abandoned first transmissions.

9. The method of claim 2 wherein information provided in step (d) includes transmitting a number of abandoned second transmissions.

10. The method of claim 2 wherein information provided in step (d) includes transmitting a number of abandoned third transmissions.

11. The method of claim 2 wherein information provided in step (d) includes transmitting a number of total failures.

12. The method of claim 2 wherein information provided in step (d) includes transmitting usage of each modulation scheme.

13. The method of claim 2 wherein information provided in step (d) includes transmitting performance of soft handover situations relative to normal situations.

14. The method of claim 2 wherein information provided in step (d) includes transmitting a number of acknowledge/non-acknowledge reception quality errors.

15. The method of claim 2 wherein information provided in step (d) includes transmitting power usage for the calculation of the power usage of HSDPA transmissions vs. all other services.

16. The method of claim 2 wherein said means for providing includes transmitting one or more of the following:

a number of unsuccessful transmissions;

a number of abandoned first transmissions;

a number of abandoned second transmissions;

a number of abandoned third transmissions;

a number of total failures;

usage of each modulation scheme;

performance of soft handover situations relative to normal situations;

a number of acknowledge/non-acknowledge reception quality errors; and

power usage for HSDPA transmissions.

17. Apparatus for enabling resource management of a radio network controller (RNC) interfaced with a Node B comprising:

said RNC having:

means for assigning resources to real time (RT) and non real time (NRT) users;

means for providing physical channel assignments to the Node B responsive to assignment of real time (RT) resources; and

means for coupling assignment of resources for NRT users to said Node B;

said Node B having:

means for providing physical channel assignments for NRT resources to a physical layer responsive to the assignment of resources for NRT users provided by the RNC; and

means for providing reports of current allocations for each NRT user to said RNC.

18. The apparatus of claim 17 wherein the Node B includes means for providing an amount of data successfully transmitted per unit time to said RNC.

19. The apparatus of claim 18 wherein the means for providing the amount of data successfully transmitted per unit time includes means for presenting one of a number of blocks of data and a size of actual data transmitted.

20. The apparatus of claim 18 wherein the means for providing includes means for transmitting a number of successful first transmissions.

21. The apparatus of claim 18 wherein the means for providing includes means for transmitting a number of successful second transmissions.

22. The apparatus of claim 18 wherein the means for providing includes means for transmitting a number of successful third transmissions.

23. A Node B for providing information required to assure proper resource management of a radio network, comprising:

a device for providing physical channel assignments for non real time (NRT) resources to a physical layer device responsive receiving an assignment of resources for NRT users; and

a device for providing reports of current allocations for each NRT for use in assuring proper resource management.

24. The Node B of claim 23 further comprising:

a device for providing physical channel requirements for real time (RT) resources to the physical layer device responsive to receiving an assignment of resources for RT users.

25. The Node B of claim 23, wherein the device for providing reports further includes providing an amount of data successfully transmitted per unit time to said RNC.

26. The Node B of claim 23, wherein the device for providing reports includes providing data representing one of a number of blocks of data and a size of actual data transmitted.

27. The apparatus of claim 23 wherein the device for providing reports further reports a number of successful first transmissions.

28. The Node B of claim 23 wherein the device for providing reports further reports a number of successful second transmissions.

29. The Node B of claim 23 wherein the device for providing reports further reports a number of successful third transmissions.

30. The Node B apparatus of claim 23 wherein the device for providing reports further provides one or more of the following:

a number of unsuccessful transmissions;
a number of abandoned first transmissions;
a number of abandoned second transmissions;
a number of abandoned third transmissions;
a number of total failures;
usage of each modulation scheme;
performance of soft handover situations relative to normal situations;
a number of acknowledge/non-acknowledge reception quality errors; and
power usage for HSDPA transmissions.

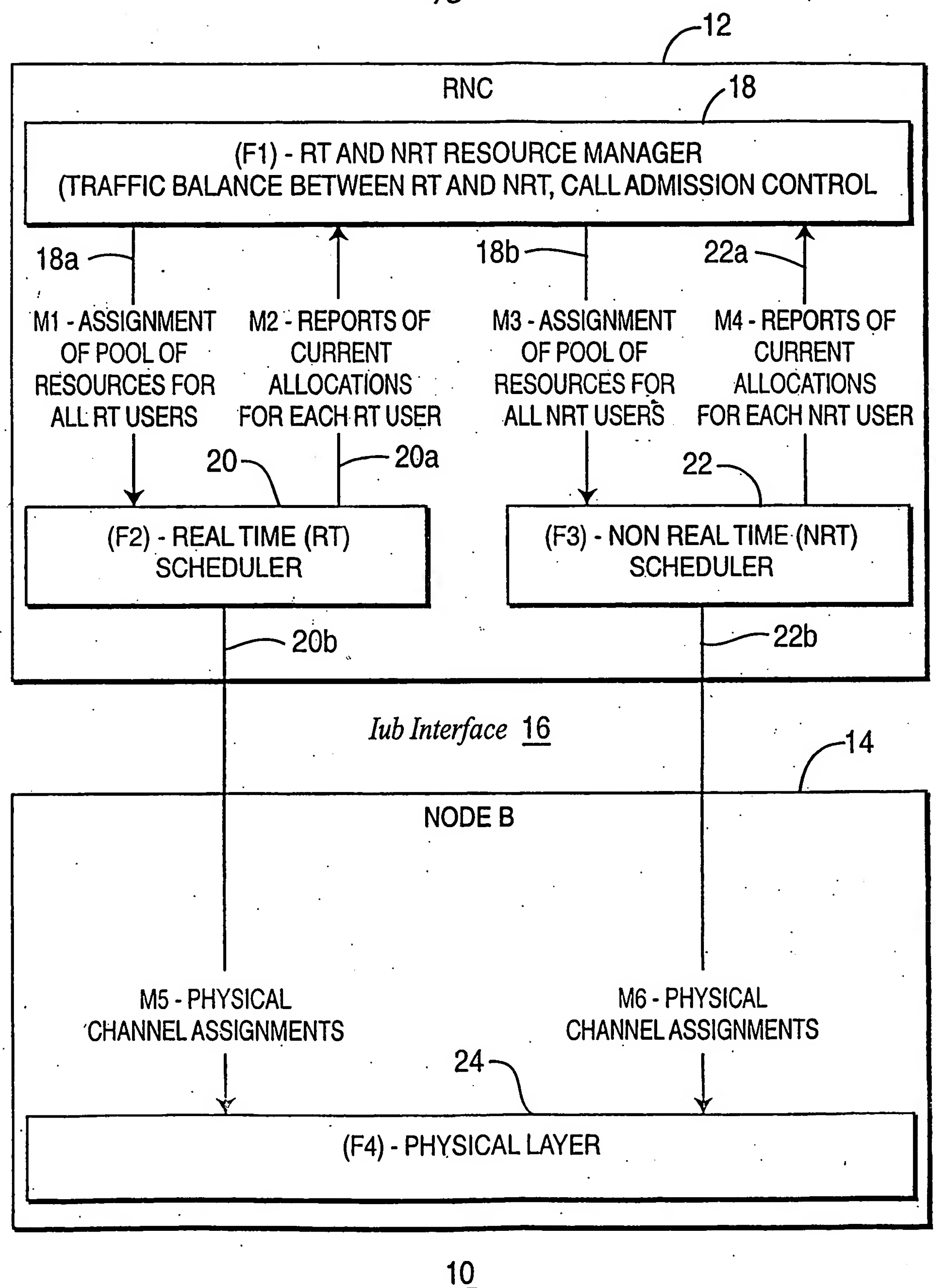

FIG. 1
PRIOR ART

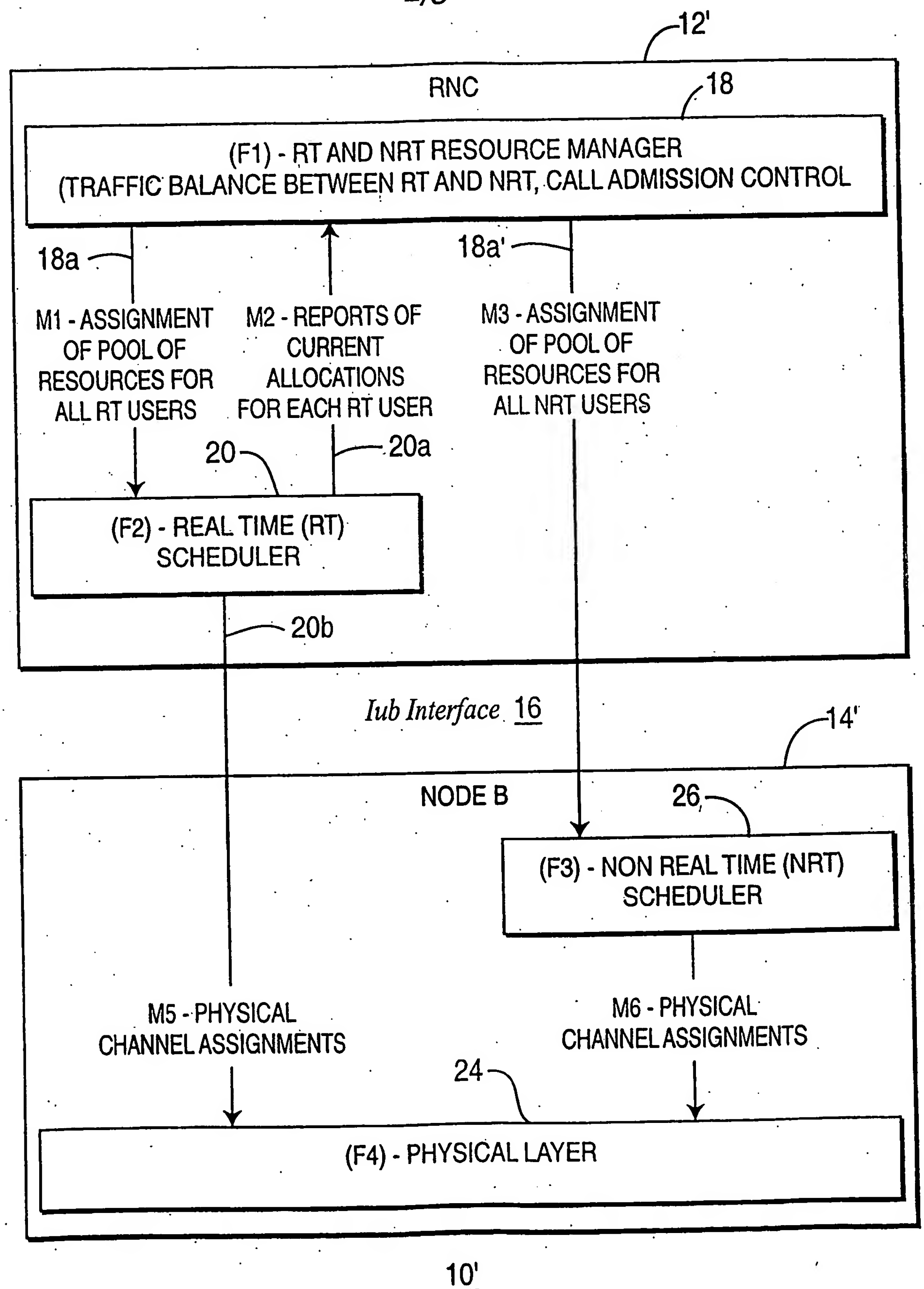
12'
RNC
18
(F1) - RT AND NRT RESOURCE MANAGER
(TRAFFIC BALANCE BETWEEN RT AND NRT, CALL ADMISSION CONTROL
18a
18a'
M1 - ASSIGNMENT OF POOL OF RESOURCES FOR ALL RT USERS
M2 - REPORTS OF CURRENT ALLOCATIONS FOR EACH RT USER
M3 - ASSIGNMENT OF POOL OF RESOURCES FOR ALL NRT USERS
20
20a
(F2) - REAL TIME (RT) SCHEDULER
20b
Iub Interface 16
14'
NODE B
26
(F3) - NON REAL TIME (NRT) SCHEDULER
M5 - PHYSICAL CHANNEL ASSIGNMENTS
M6 - PHYSICAL CHANNEL ASSIGNMENTS
24
(F4) - PHYSICAL LAYER
10'

FIG. 2

3/3

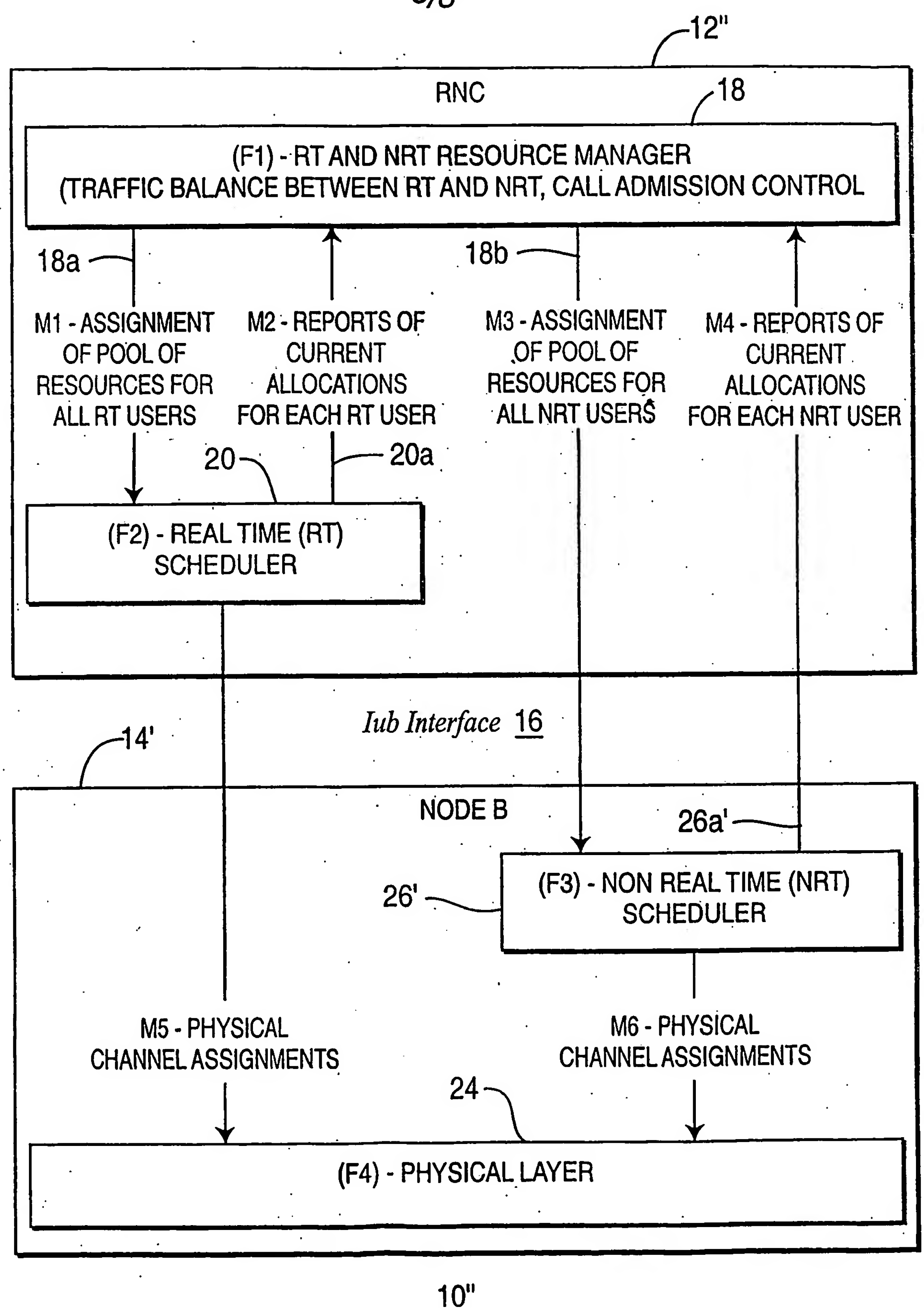
12"
RNC
18
(F1) - RT AND NRT RESOURCE MANAGER
(TRAFFIC BALANCE BETWEEN RT AND NRT, CALL ADMISSION CONTROL
18a
18b
M1 - ASSIGNMENT OF POOL OF RESOURCES FOR ALL RT USERS
M2 - REPORTS OF CURRENT ALLOCATIONS FOR EACH RT USER
M3 - ASSIGNMENT OF POOL OF RESOURCES FOR ALL NRT USERS
M4 - REPORTS OF CURRENT ALLOCATIONS FOR EACH NRT USER
20
20a
(F2) - REAL TIME (RT) SCHEDULER
Iub Interface 16
14'
NODE B
26a'
26'
(F3) - NON REAL TIME (NRT) SCHEDULER
M5 - PHYSICAL CHANNEL ASSIGNMENTS
M6 - PHYSICAL CHANNEL ASSIGNMENTS
24
(F4) - PHYSICAL LAYER
10"

FIG. 3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US03/10070

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04Q 7/38, 11/04

US CL : 370/329, 331; 455/436, 442, 450, 509, 67.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/328, 329, 331, 332; 455/422, 436, 442, 450, 38.3, 509, 522, 67.1, 343

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99/41925 A1 (VIALEN et al) 19 August 1999, see page 12, line 1 to page 15, line 2.	23-30
A	WO 99/37114 A2 (VIALEN et al) 22 July 1999, see entire document.	1-30
A	US 2001/0018342 A1 (VIALEN et al) 30 August 2001, see entire document.	1-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2003 (23.06.2003)	17 JUL 2003
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Alpus H. Hsu Telephone No. (703)305-4700 Eugenia Logan

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

PCT/US03/10070

Continuation of Item 4 of the first sheet:
COORDINATION OF RADIO NETWORK CONTROLLER AND NODE B RESOURCE MANAGEMENT

Continuation of B. FIELDS SEARCHED Item 3:
EAST Search terms: radio adj networ adj controller or rnc, node, real adj time or rt, non adj real adj time or nrt, channel near3 (assign$3 or allocat$4), power, (handover or handoff), acknowledg$5